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Investigation into the visual perceptive ability of anaesthetists during ultrasound-guided interscalene and femoral blocks conducted on soft embalmed cadavers: a randomised single-blind study

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Abstract

Background: Errors may occur during regional anaesthesia whilst searching for nerves, needle tips, and test doses. Poor visual search impacts on decision making, clinical intervention, and patient safety.
Methods: We conducted a randomised single-blind study in a single university hospital. Twenty trainees and two consultants examined the paired B-mode and fused B-mode and elastography video recordings of 24 interscalene and 24 femoral blocks conducted on two soft embalmed cadavers. Perineural injection was randomised equally to 0.25, 0.5, and 1.0 ml volumes. Tissue displacement perceived on both imaging modalities was defined as 'target' or 'distractor'. Our primary objective was to test the anaesthetists' perception of the number and proportion of targets and distractors on B-mode and fused elastography videos collected during femoral and sciatic nerve block on soft embalmed cadavers. Our secondary objectives were to determine the differences between novices and experts, and between test-dose volumes, and to measure the area and brightness of spread and strain patterns.
Results: All anaesthetists recognised perineural spread using 0.25 ml volumes. Distractor patterns were recognised in 133 (12%) of B-mode and in 403 (38%) of fused B-mode and elastography patterns; $P<0.001$. With elastography, novice recognition improved from 12 to 37% ($P<0.001$), and consultant recognition increased from 24 to 53%; $P<0.001$. Distractor recognition improved from 8 to 31% using 0.25 ml volumes ($P<0.001$), and from 15 to 45% using 1 ml volumes ($P<0.001$).

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Conclusions: Visual search improved with fusion elastography, increased volume, and consultants. A need exists to investigate image search strategies.

Keywords: cadaver; elastography; regional anaesthesia; ultrasonography

Editor's key points

- Elastography is an ultrasound-based technology that cross-correlates radiofrequency waves before and after tissue displacement, and displays relative displacement (strain) in colour.
- Compared with B-mode ultrasound, B-mode plus elastography video recording may facilitate successful peripheral nerve blocks.

Errors may occur during the visual search, recognition, and decision-making phases[1] of ultrasound-guided regional anaesthesia (UGRA) nerve block. Search errors are attributable to failure to see lesions that are normally noticed by anaesthetists.[2] With recognition errors, lesions are seen, but confusing and decision errors occur when a lesion is fixated on for long periods, but the anaesthetist either does not recognise features or dismisses them.[3]

Elastography is an ultrasound-based technology that cross-correlates radiofrequency waves before and after tissue displacement, and displays relative displacement (strain) in colour. Whilst conducting interscalene and femoral nerve block in cadavers[4] and patients,[5] we noticed novel features on paired B-mode and elastography ultrasound images in response to injection of test doses. Tissue strain intermittently presented as two patterns instead of one.[6] Additional patterns, termed *distractors*, were distinguished from primary target displacement patterns by brightness, size, position, or movement.[7] In contrast, test doses as low as 0.25 ml were always seen on B-mode images, but distractor patterns much less so. Our impression was that elastography exhibited greater saliency, the extent to which a location differs from its surroundings, than B-mode images because, first, key regions differed in brightness, colour, orientation, and motion, and that, second, anaesthetists' visual attention was attracted towards these features.

Visual salience describes the visual-processing mechanism that enables the brain to select important features that stand out from other items or locations[8] (Table 1). Salience is associated with passive, automatic visual search or 'bottom-up processing' rather than cognitive, goal-driven 'top-down processing'.[9] Consideration of both processes creates a saliency map, a topographic representation of relative stimulus strength and behavioural importance. This map is distributed throughout the visual cortex, and linked via the oculomotor system to eye movement and gaze.[10] Eye-gaze characteristics, such as fixations and saccades, are quantified using an eye-tracking technology and are used in many industries to measure technical performance.

Visual search and salience differ between experts and novices. Experts rely on bottom-up processes that facilitate efficient search, albeit mediated by prior knowledge when encountering novel stimuli.[9] Novices, in contrast, are primarily goal driven, but can be salience led to very obvious targets.

We hypothesised that improvements in novice visual perception were salience driven, and, if so, would provide the evidence for investigation of the role of eye-gaze technology and augmented reality during simulator training. This approach could help train anaesthetists better, target local anaesthetic more, and improve patient safety.

Our primary objective was to test anaesthetists' perception of the number and proportion of targets and distractors on B-mode and fused elastography videos collected during femoral and sciatic nerve block on soft embalmed cadavers.

Table 1 Psychological terms and descriptors

Term	Description
Visual search	Task of looking for a target in a cluttered visual environment; non-target items are termed distractors
Visual salience	Distinct subjective perceptual quality, which makes some items in the world stand out from their neighbours and immediately grab our attention
Guiding attribute	Visual properties that can be used to direct deployment of attention
Saliency	The extent to which a location differs is from its surroundings with respect to guiding attributes, such as colour, orientation, and motion
Saliency map	Topographically arranged map that represents the visual saliency of a scene
Visual attention	Process used to select stimuli
Change blindness	Failure to notice something different about a display
In attentional blindness	Failure to notice a fully visible, but unexpected object because attention was engaged on another task, event, or object
Bottom-up attention	Factors that depend only on instantaneous sensory input, without taking into account the goals, personal history, and experiences
Top-down attention	Factors that take into account goals, personal history, and experiences; bottom-up salience can be modified by top-down goals of the searcher